Ballistic Helmet

A Novel Test Methodology to Assess the Performance of Ballistic Helmets

Presented by:
B. Anctil

Co-authors:
M. Keown
Biokinetics and Associates Ltd.

D. Bourget and G. Pageau
Defence R&D Canada

22nd International Symposium on Ballistics
Vancouver, Canada, November 14-18, 2005

Biokinetics

The Problem

- New lightweight composite helmets have increased protection against penetration
- Result in large back-face deformation
- Increased risk of serious skull/brain injuries
- No widely accepted evaluation procedure

BIOKINETICS

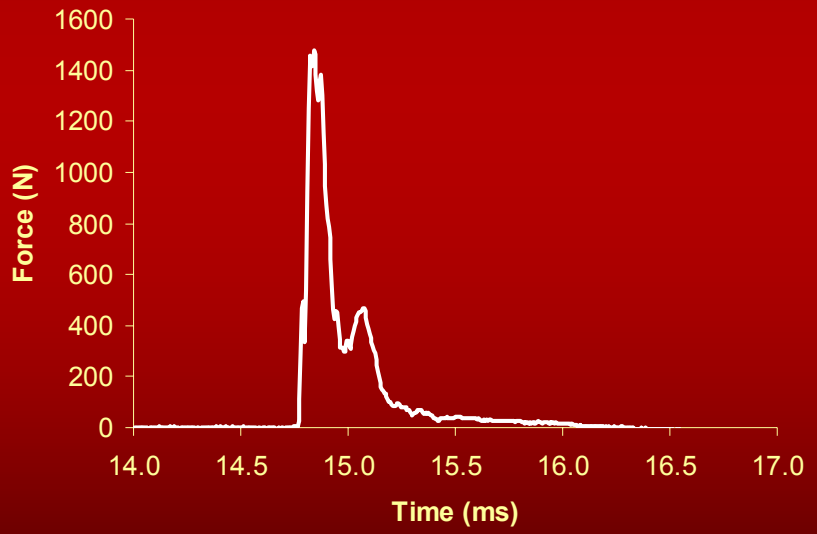
Our Strategy

- Implement an impact force measurement headform
- Based on injury model developed by Bass et al. (2003) using localized skull pressure data
- Develop test procedure
- Conduct experimental trials with current combat helmet models
- Define injury function

BIOKINETICS

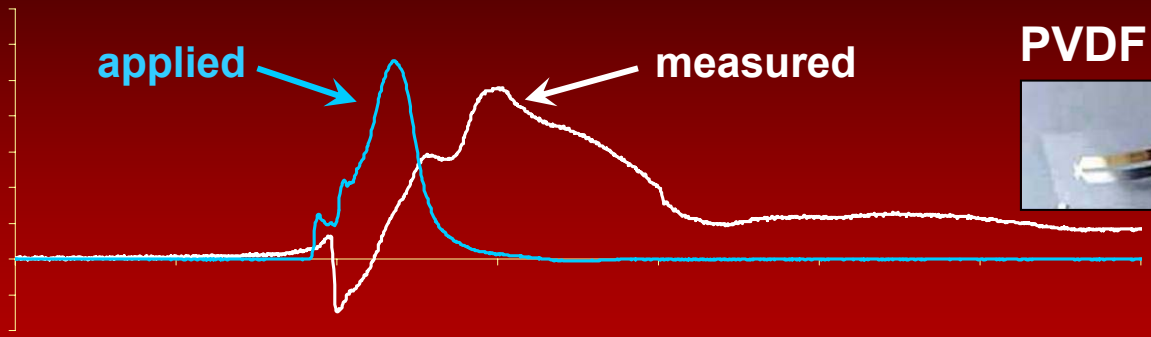
Measurement System Requirements

- Dynamic Loads
  - *Force < 5,000 N*
  - *Duration < 2 ms*
- PVDF gauge
- Load cell
- Evaluation under ballistic loading conditions

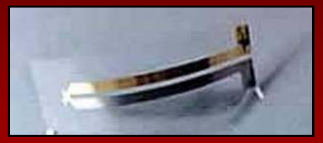


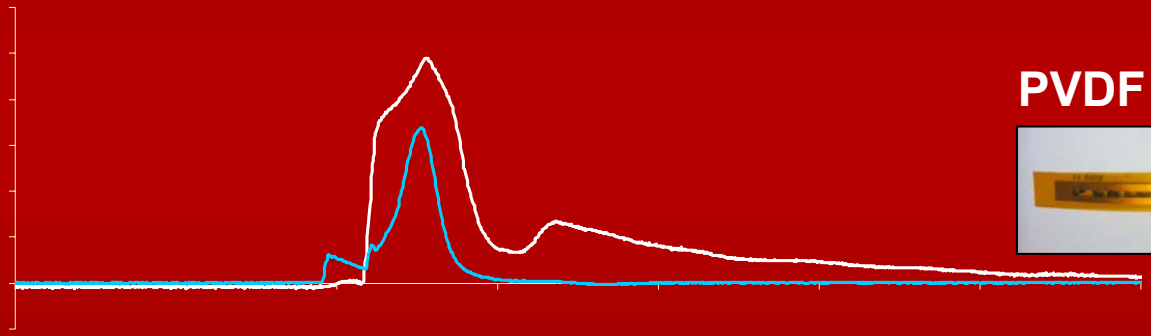
BIOKINETICS

Instrumentation Selection

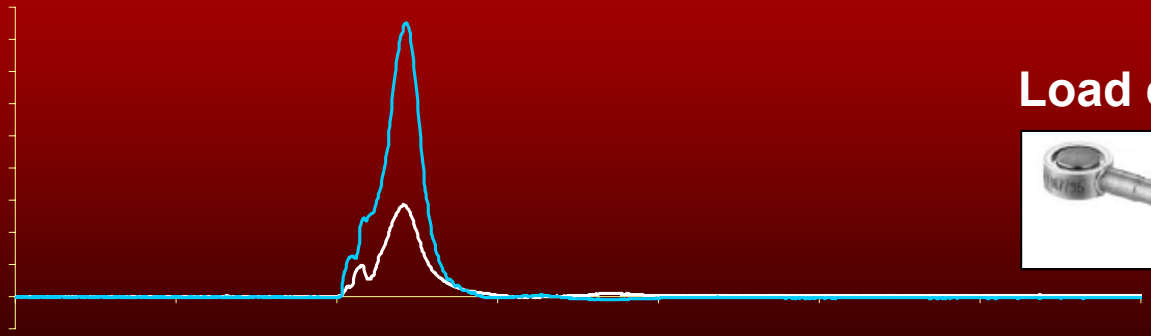


PVDF Gauge (Ktech)



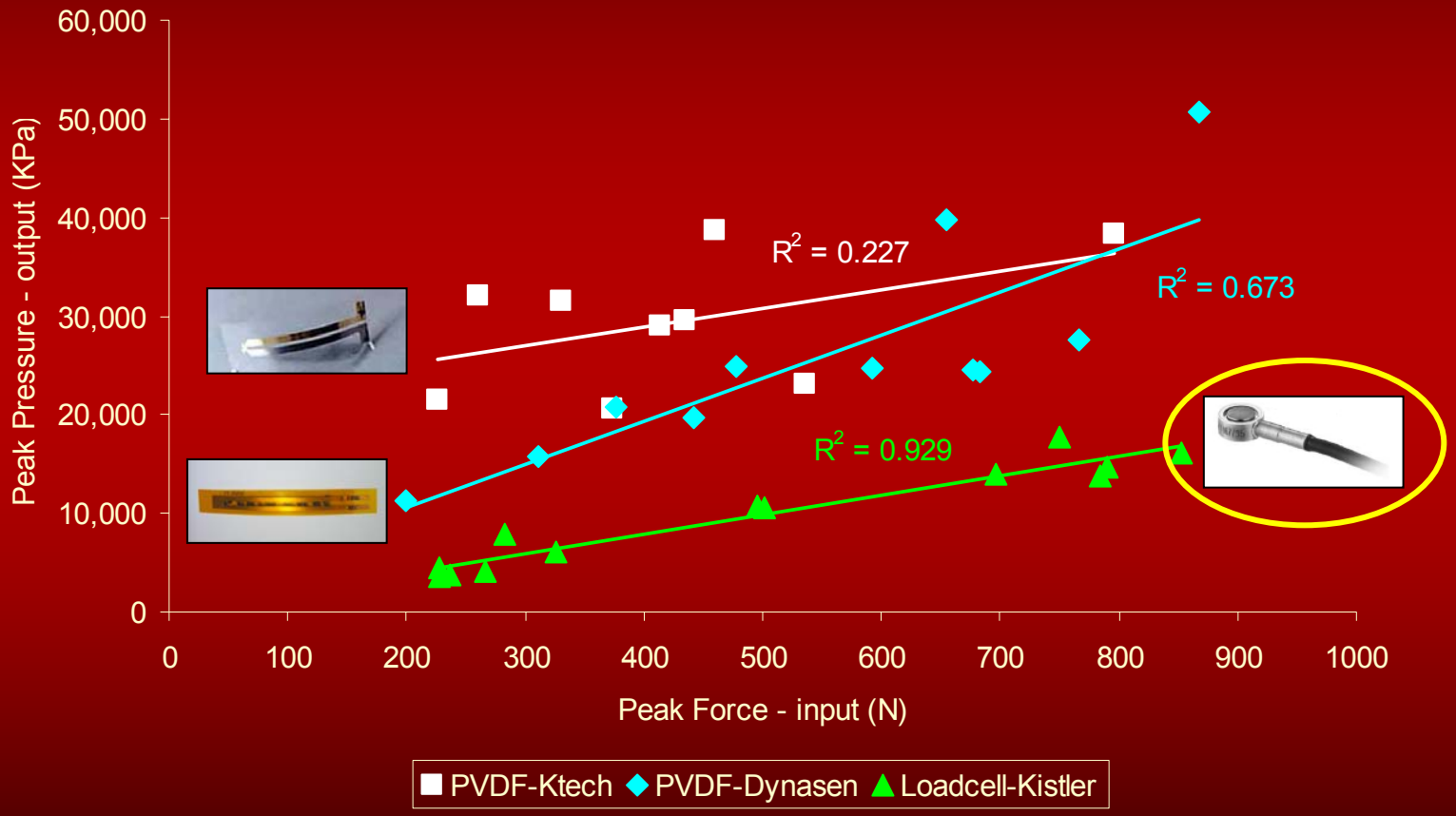


PVDF Gauge (Dynasen)

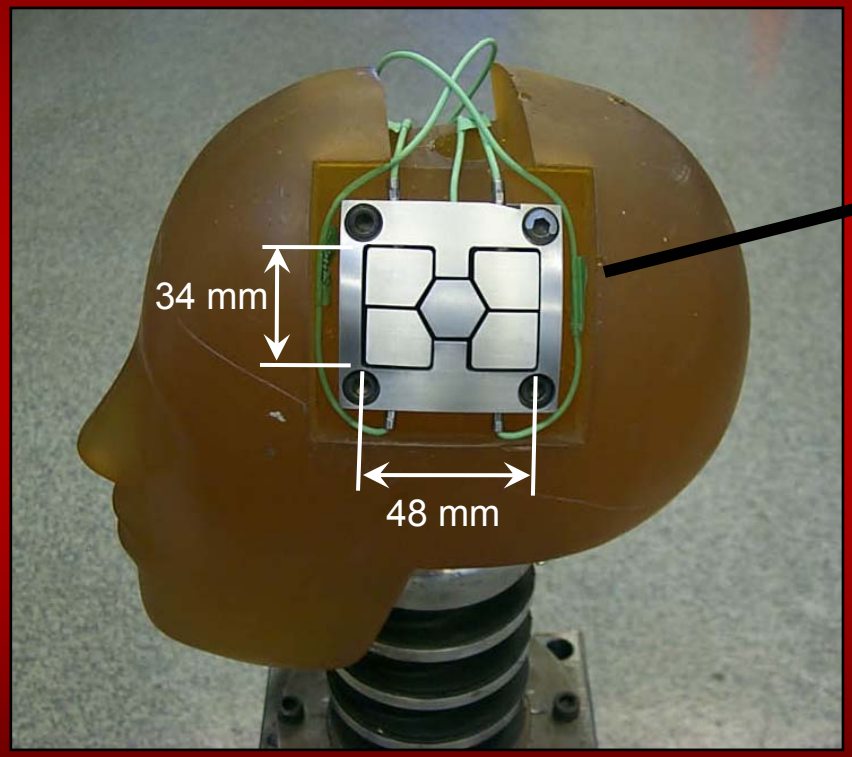


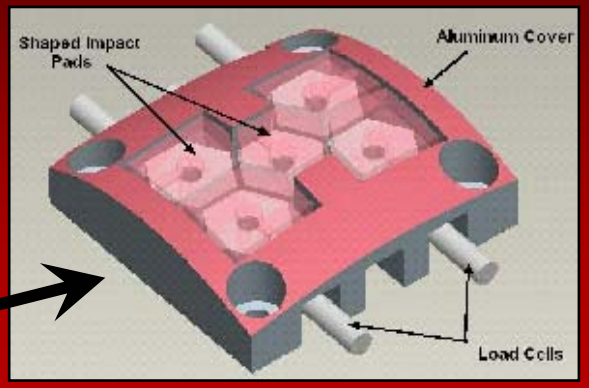
Load cell (Kistler)

Force applied vs. measured

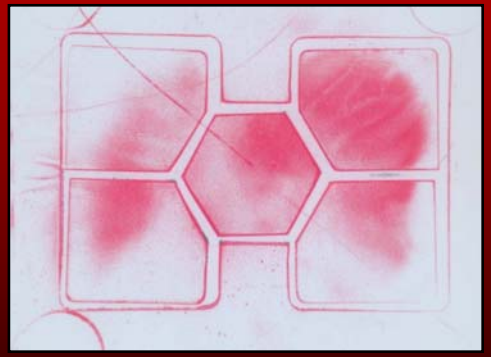


Impact Force Measurement Headform





Pressure sensitive film to measure loading area



Helmet Performance Evaluation

- 3 Combat Helmet Models
- Similar Ballistic Limit (V_{50})
- 9mm FMJ
- 350 m/s < v < 450 m/s

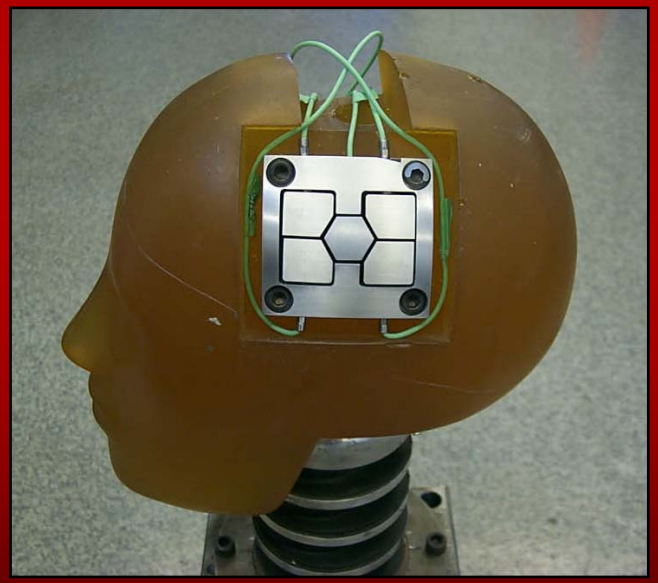
Helmet A

Helmet B

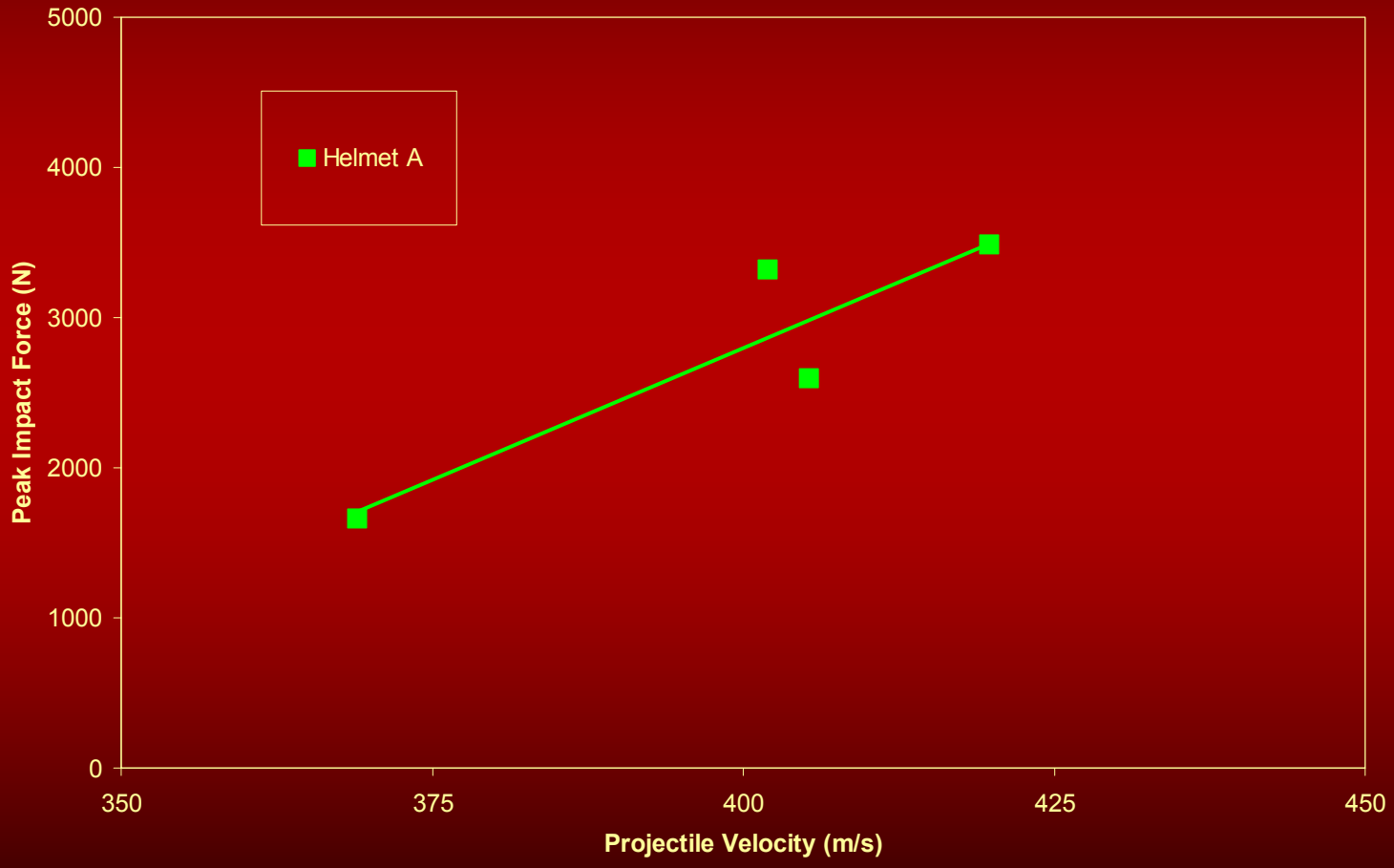
Helmet C

Headform Response

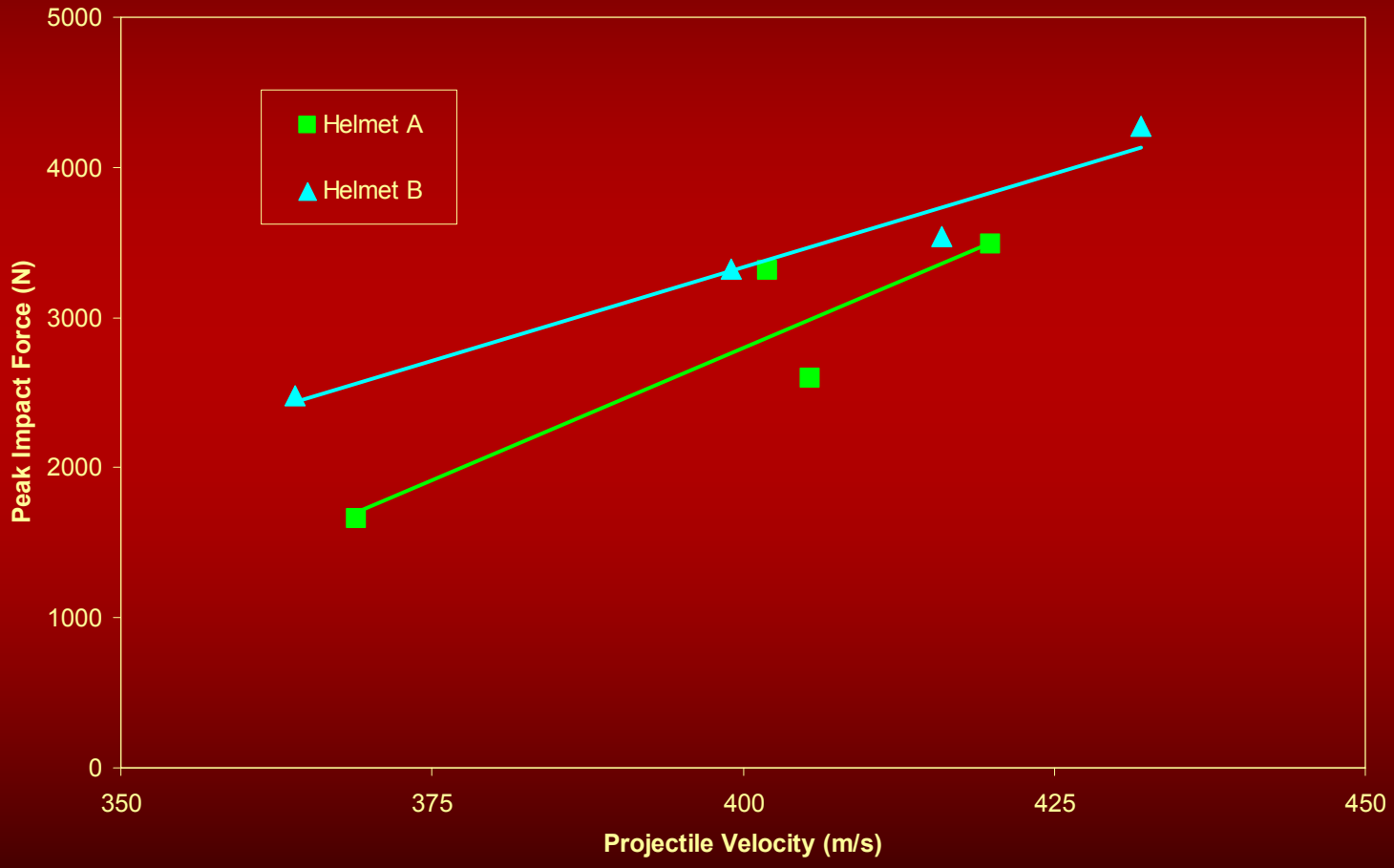
- Peak Force of Individual Load Cells
- Peak Force of Sum of Load Cells
- Impulse



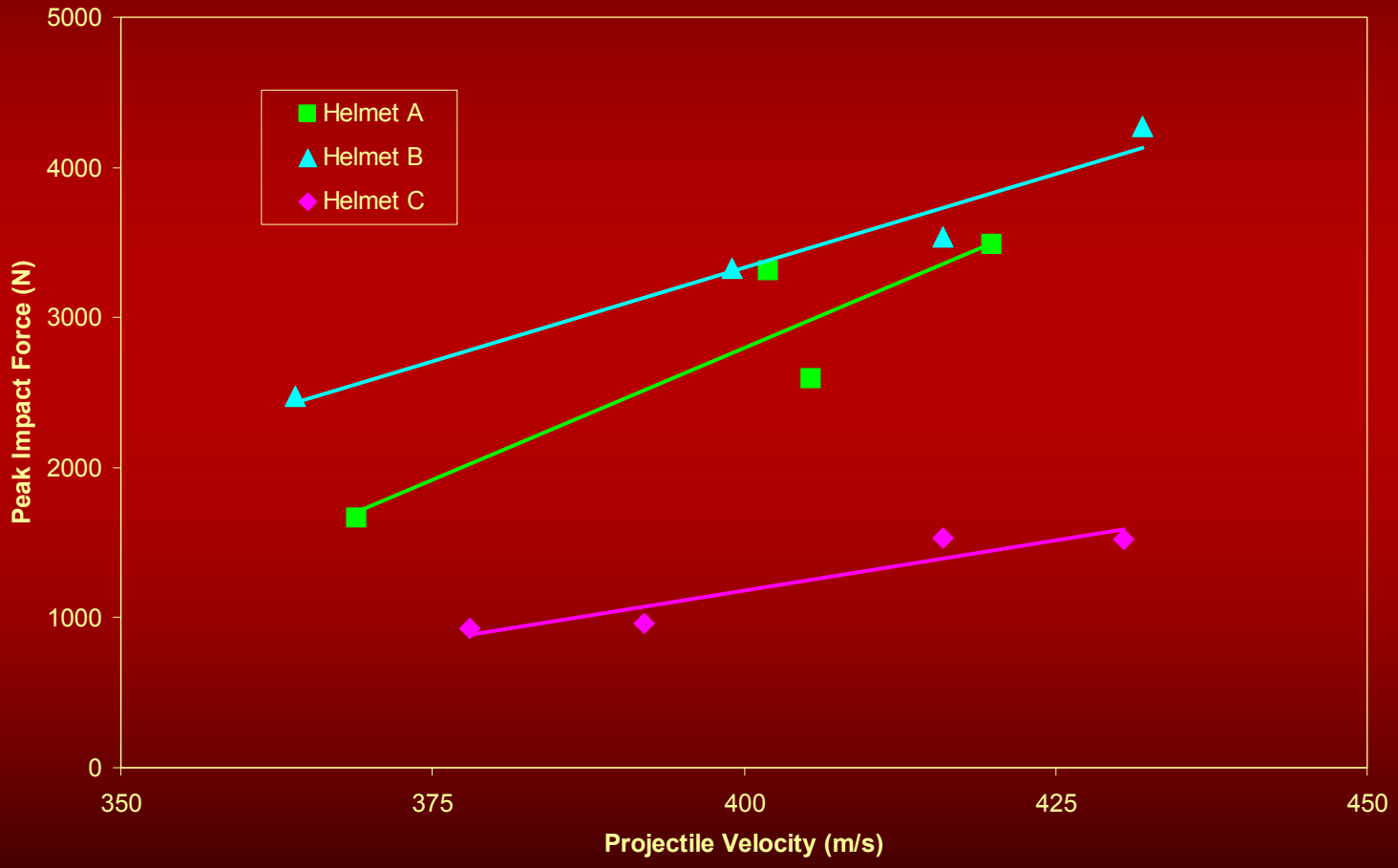
Individual Peak Forces



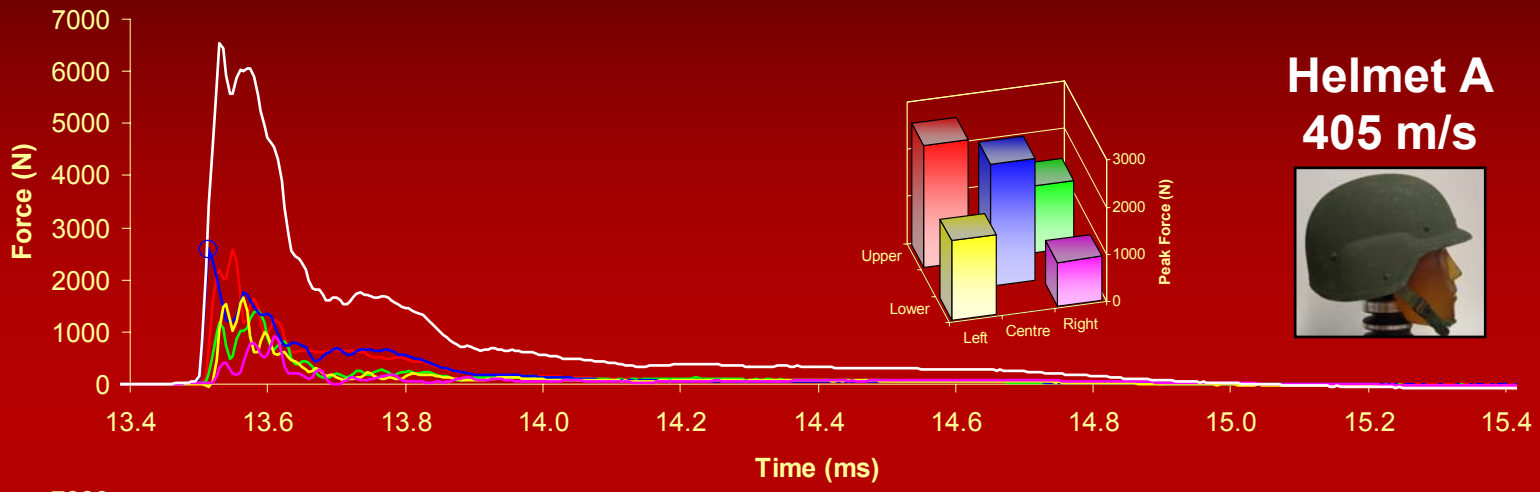
Individual Peak Forces



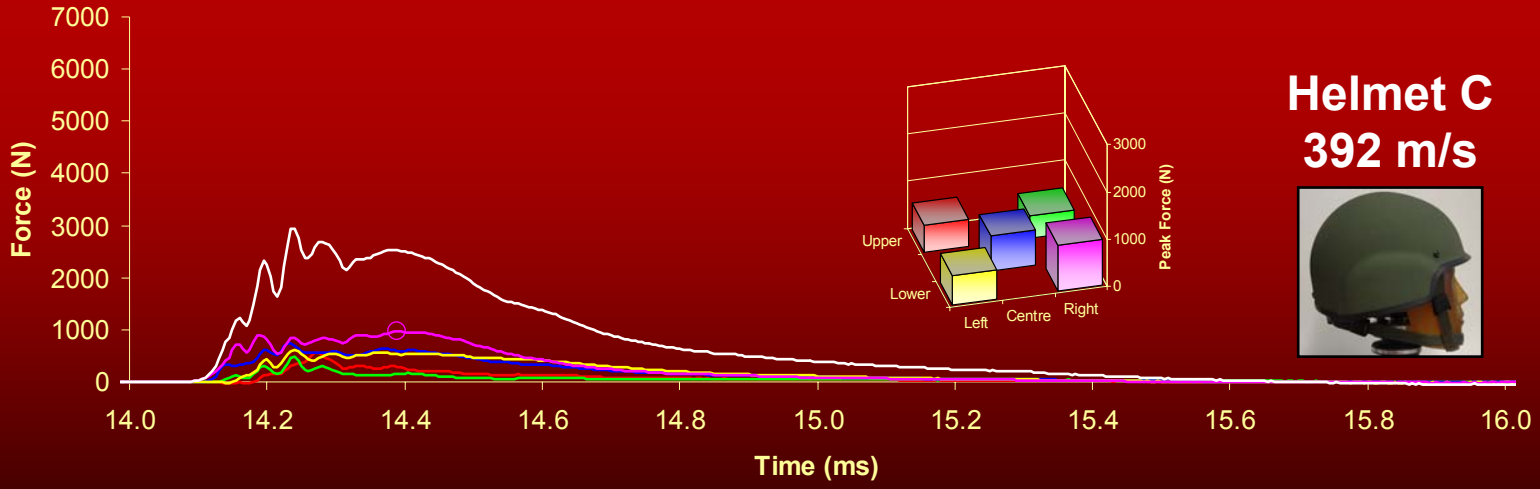
Individual Peak Forces



Impact Force Measurements

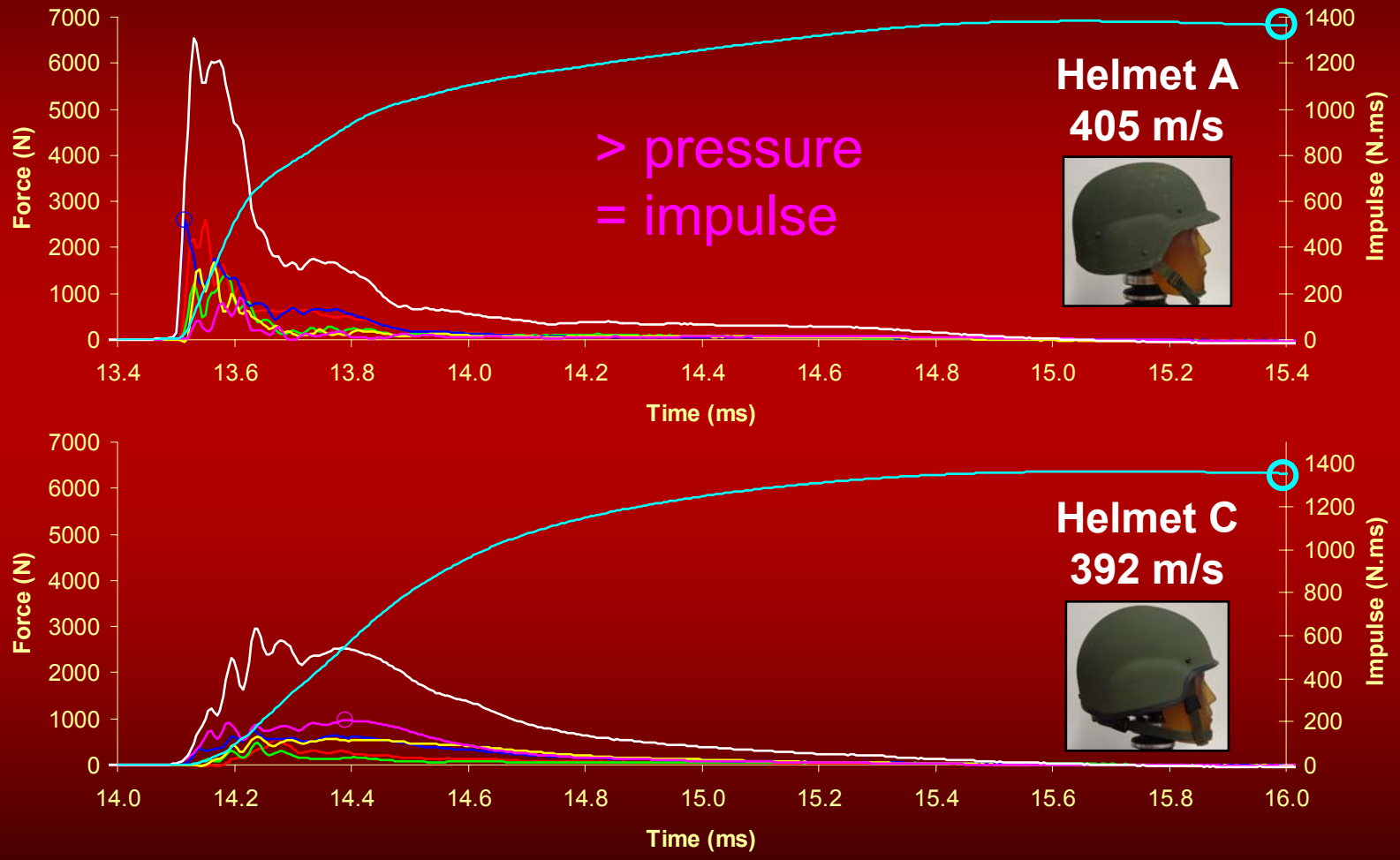


Helmet A
405 m/s

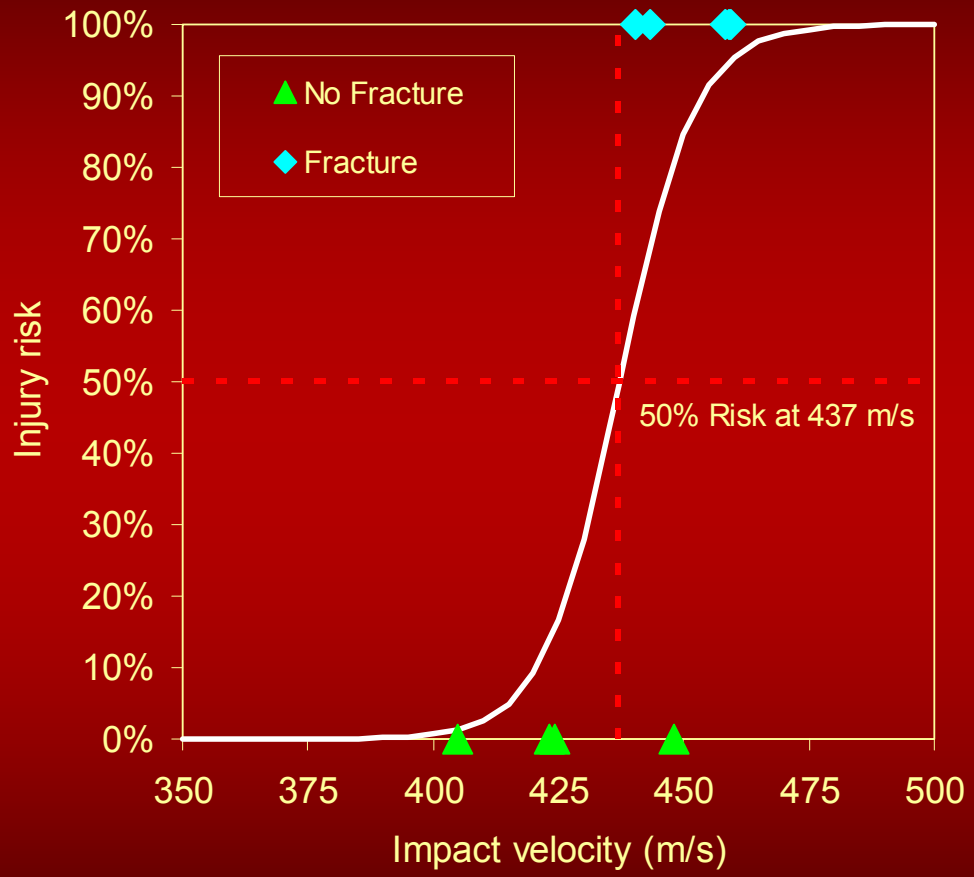


Helmet C
392 m/s

Impulse

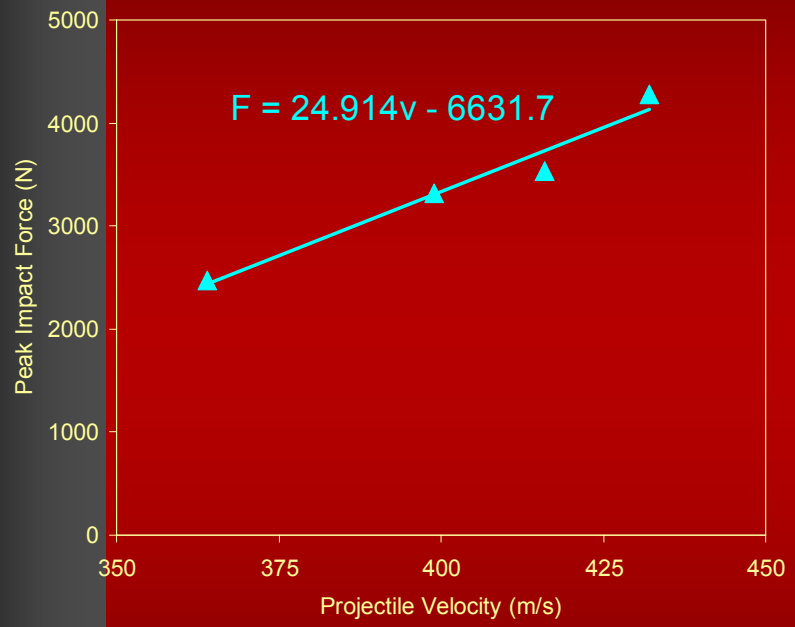

Force (N)
Impulse (N.ms)
Time (ms)
> pressure
= impulse
Helmet A
405 m/s
Helmet C
392 m/s

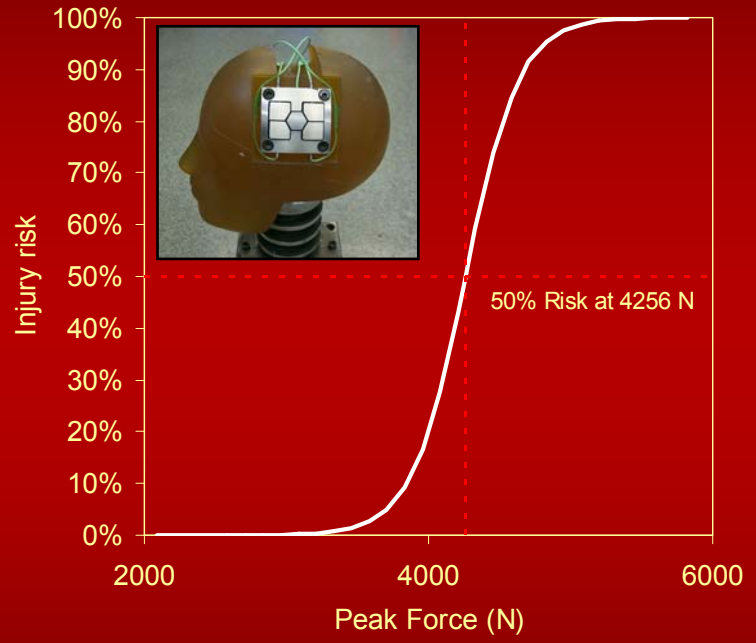
Skull Fracture Injury Function



Helmet B / PMHS (Bass et al. 2003)

Transfer Function

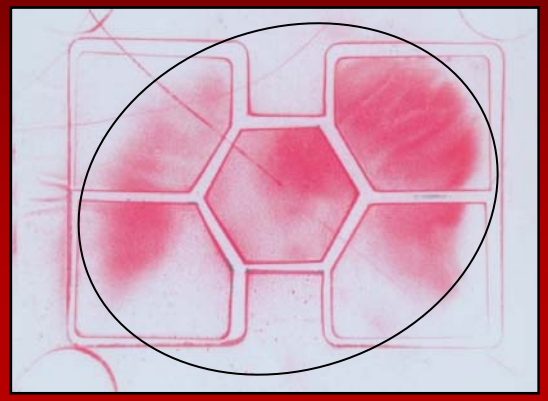


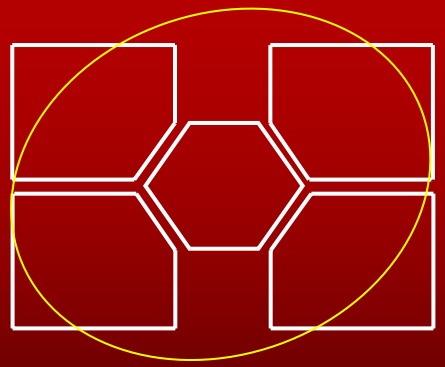


Force vs. velocity

valid only for concentrated load

Load Distribution





$$P_e = \frac{\sum_{i=1}^{5} F_i(t)}{A_e}$$

Average Peak Pressure

Conclusions

- Miniature load cell suitable to measure helmet backface loading
- Instrumented headform was able to quantify the performance of ballistic helmets
- Can be used to predict the risk of skull fracture

Limitations

- Injury function valid only for concentrated load
- Contact area > sensing area
- Peak force must be within sensing area
- Does not address distributed forces (rigid helmets)

Way ahead

- Additional impact locations (e.g. front, rear)
- Consider other measurements (head acceleration)
- Review data analysis procedure (peak, sum, impulse)
- Calibration procedure
- Laboratory re-enactments of injurious cases

Acknowledgment

- This work was supported by
  - *Defence R&D – Valcartier*
  - *Directorate of Land Requirements of DND Canada*
  - *International Counter Terrorism Research and Development Program Agreement between US and Canada*
  - *OLES and NIJ*

- Co-authors
  - *M. Keown (Biokinetics and Associates Ltd.)*
  - *D. Bourget and G. Pageau (Defence R&D Canada)*

Engineered Solutions for Impact Protection

BIOKINETICS

Contact Information

- Name: Benoit Anctil
- Phone No.: (613) 736-0384 ext.223
- Company: Biokinetics and Associates Ltd.
- E-mail: anctil@biokinetics.com